# REPORT DOCUMENTATION PAGE

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| Ilya Nemenman | |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |

| 7. PERFORMING ORGANIZATION NAMES AND ADDRESSES | 8. PERFORMING ORGANIZATION REPORT NUMBER |
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| Emory University 1599 Clifton Road NE, 4th Floor 1599-001-1BA Atlanta, GA 30322 -4250 | |

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## 14. ABSTRACT

Automatic object recognition from still imagery, insensitive to clutter and partial occlusion, is an unsolved computer vision problem with countless applications to military readiness. Ambiguity of segmentation of complex images into objects is the major stumbling block. Incorporation of certain structural features of the primate early visual system into computational models has been suggested as a potential solution. However, little is known about effects of these features on segmentation performance of either humans or computational models. For this, in this project, we have quantified importance of lateral neural connectivity for image context analysis. We showed that

| 15. SUBJECT TERMS |
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| segmentation, simulations, director field models |

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 15. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON Ilya Nemenman |
|---|---|---|---|---|---|
| a. REPORT UU | b. ABSTRACT UU | c. THIS PAGE UU | UU | | 19b. TELEPHONE NUMBER 404-727-9286 |

Standard Form 298 (Rev 8/98)
Prescribed by ANSI Std. Z39.18

Final Report: Improving image segmentation with adaptive, recurrent, spiking neural network models of the primary visual cortex

**ABSTRACT**

Automatic object recognition from still imagery, insensitive to clutter and partial occlusion, is an unsolved computer vision problem with countless applications to military readiness. Ambiguity of segmentation of complex images into objects is the major stumbling block. Incorporation of certain structural features of the primate early visual system into computational models has been suggested as a potential solution. However, little is known about effects of these features on segmentation performance of either humans or computational models. For this, in this project, we have quantified importance of lateral neural connectivity for image context analysis. We showed that simple models of lateral connectivity in computational models make their performance comparable to those of humans.

## Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

### (a) Papers published in peer-reviewed journals (N/A for none)

| Received | | Paper |
|---|---|---|
| 05/19/2017 | 1 | Vijay Singh, Martin Tchernookov, Rebecca Butterfield, Ilya Nemenman, Rongrong Ji. Director Field Model of the Primary Visual Cortex for Contour Detection, PLoS ONE, ( ): . doi: |
| | | 1,041,544.00 |
| **TOTAL:** | **1** | |

**Number of Papers published in peer-reviewed journals:**

### (b) Papers published in non-peer-reviewed journals (N/A for none)

| Received | Paper |
|---|---|
| **TOTAL:** | |

**Number of Papers published in non peer-reviewed journals:**

### (c) Presentations

## Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received          Paper

**TOTAL:**

**Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):**

## Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received          Paper

**TOTAL:**

**Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):**

## (d) Manuscripts

Received          Paper

**TOTAL:**

**Number of Manuscripts:**

## Books

Received          Book

**TOTAL:**

**TOTAL:**

# Patents Submitted

# Patents Awarded

# Awards

## Graduate Students

| NAME | PERCENT_SUPPORTED | DISCIPLINE |
|------|-------------------|------------|
| Vijay Singh | 40 | Physics |
| **FTE Equivalent:** | **0.40** | |
| **Total Number:** | **1** | |

## Names of Post Doctorates

| NAME | PERCENT_SUPPORTED |
|------|-------------------|
| Martin Tchernookov | 0.20 |
| **FTE Equivalent:** | **0.20** |
| **Total Number:** | **1** |

## Names of Faculty Supported

| NAME | PERCENT_SUPPORTED | National Academy Member |
|------|-------------------|-------------------------|
| Ilya Nemenman | 0.08 | |
| **FTE Equivalent:** | **0.08** | |
| **Total Number:** | **1** | |

## Names of Under Graduate students supported

| NAME | PERCENT_SUPPORTED | DISCIPLINE |
|------|-------------------|------------|
| Rebecca Butterfield | 8 | CS/Neuroscience |
| **FTE Equivalent:** | **0.08** | |
| **Total Number:** | **1** | |

## Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: ...... 1.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 1.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 1.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense ...... 1.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:...... 1.00

## Names of Personnel receiving masters degrees

NAME

**Total Number:**

## Names of personnel receiving PHDs

NAME
Vijay Singh

**Total Number:** 1

## Names of other research staff

NAME                    PERCENT_SUPPORTED

**FTE Equivalent:**
**Total Number:**

## Sub Contractors (DD882)

## Inventions (DD882)

## Scientific Progress

Main goal of the project was to analyze the importance of (simplified models of) lateral connectivity, observed in the primate visual system, on the performance of artificial image segmentation programs. We achieved the goal of showing that such models reach performance of human subjects on segmentation studies. A publication in PLoS ONE documented the finding.

Automatic object recognition from still imagery, insensitive to clutter and partial occlusion, is an unsolved computer vision problem with countless applications to military readiness. Ambiguity of segmentation of complex images into objects is the major stumbling block. Incorporation of certain structural features of the primate early visual system into computational models has been suggested as a potential solution. However, little is known about effects of these features on segmentation performance of either humans or computational models. For this, in this project, we have quantified importance of lateral neural connectivity for image context analysis. We showed that such models reach performance of human subjects on segmentation studies.

## Technology Transfer